

# UNIQAIR

We at Uniqair are proudly manufacturing the world's most advanced and effective cold plasma injection systems with 24 years of cold plasma odor control experience in the America's, Asia and Europe.

## PLASMA-INJECTOR™ SUSTAINABLE ODOR CONTROL

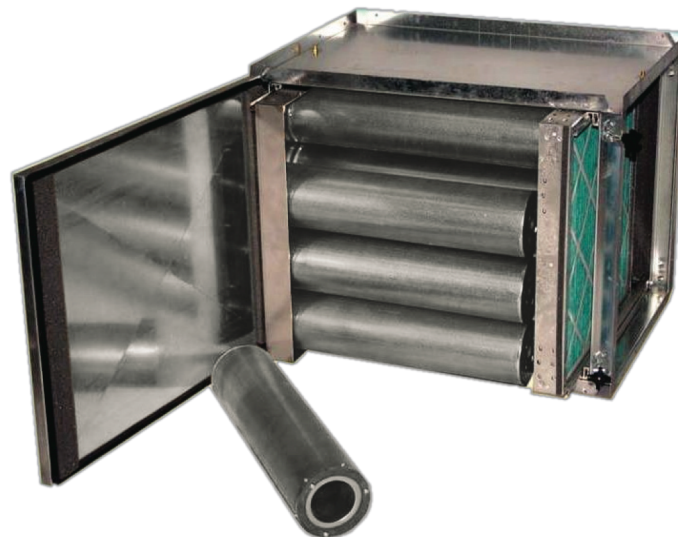
Unlike chemical scrubbers, biofilters or incinerators  
our PLASMA-INJECTOR is a sustainable oxidizer that controls odor  
without the use of any water, chemicals or waste.

UNIQAIR Technologies Ltd

Tel: (+1) 604-854-5628

[www.UNIQAIR.com](http://www.UNIQAIR.com)

[info@uniqair.com](mailto:info@uniqair.com)



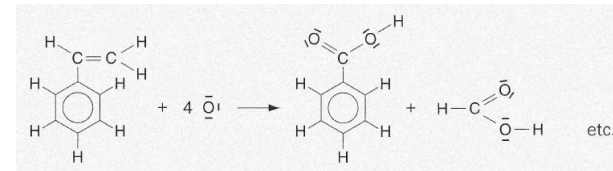
Patented VENTURI-PLASMA technology

**UNIQAIR**.COM  
UNIQUE AIR PURIFICATION

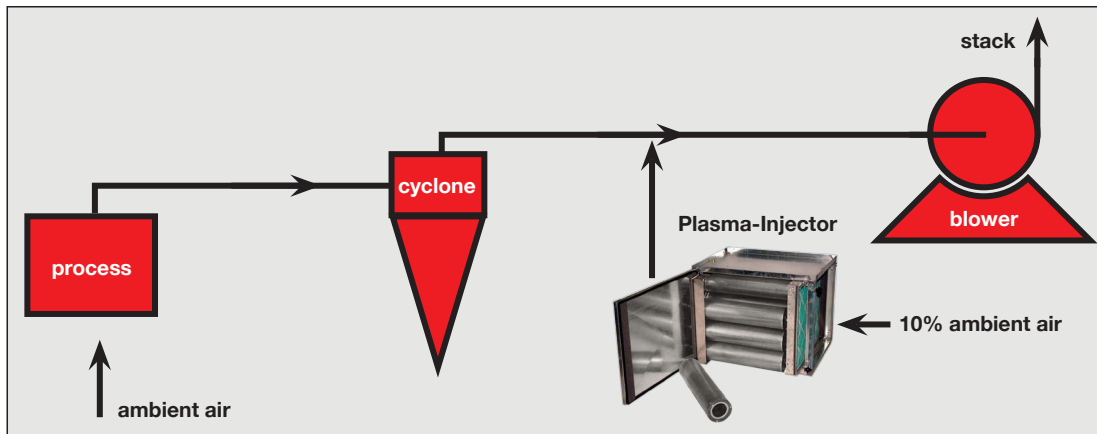
# PLASMA-INJECTOR: just like nature only faster

Odor control with Reactive Oxygen Species (ROS) and Reactive Nitrogen Species (RNS): O-, OH-radicals, H2O2, N2O3, etc., generated from humid ambient air for high speed oxidation inside the duct/fan/stack: fast oxidation.

- No water or any chemicals.
- No waste and no moving parts.
- Low energy: app. 6 kW per 10,000 cfm or 17,000 m3/h.
- Simple on/off control



Example of an odor molecule partial oxidation

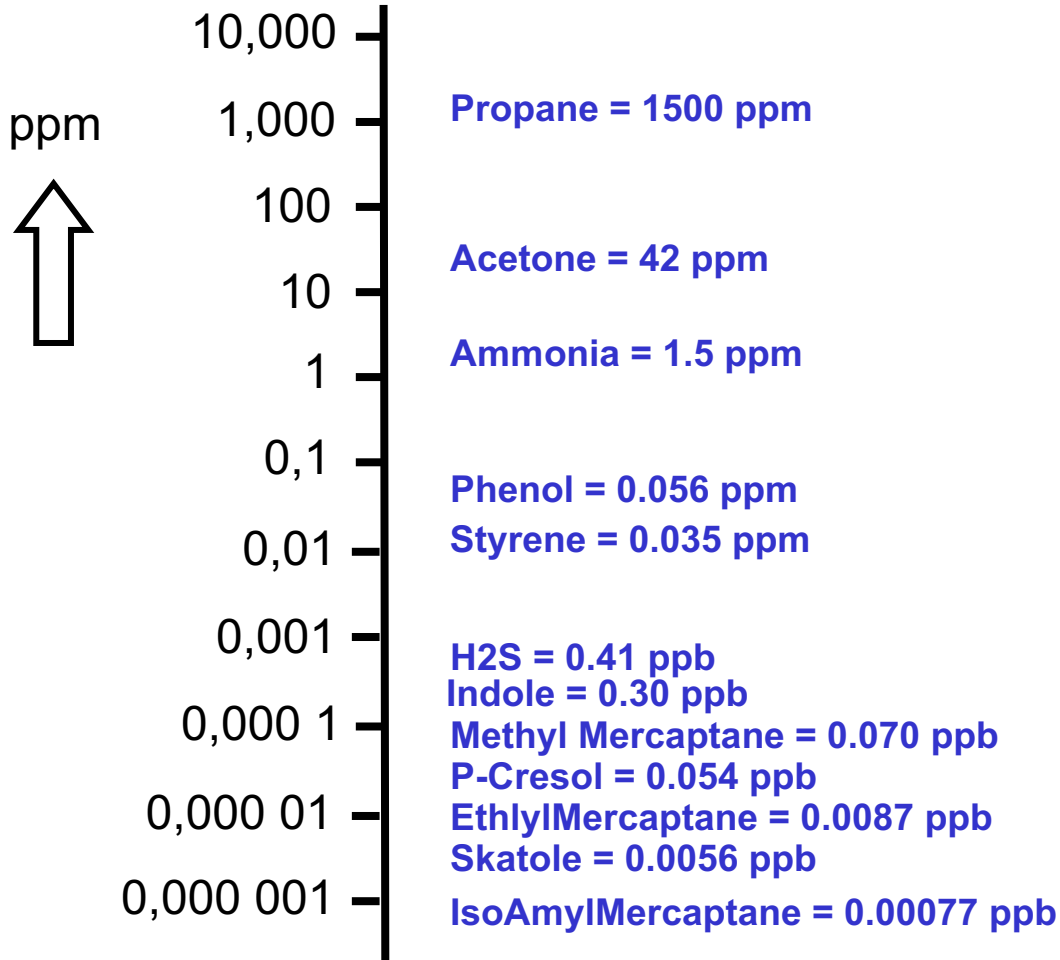


Example process schematic: injection of ROS and RON into the exhaust duct for oxidation.

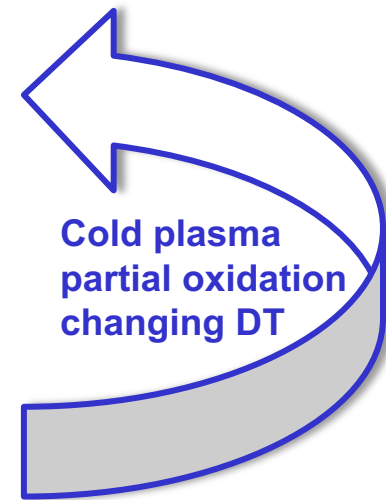
# WHAT MAKES ODOR COMPLICATED?

- Often it is a **cocktail** of hundreds different organic components.
- The weight **concentration (ppm) is mostly very low**, but the odor-concentration (ou/m<sup>3</sup> or DT = number of required dilutions with clean air in order to just become odor free) can be very high.
- The odor-components with the lowest concentrations (sub-ppb-range) **cannot all be detected analytically (GC or GCMS, etc)** but the human nose may very well notice them. So by this way it is impossible to make accurate calculations or predictions on odor-emission.
- Each odor-component can **mask or amplify** another component within the cocktail.
- Odor is **dynamic**, since the components and their concentrations can vary in time due to small differences in process conditions, raw material quality, weather conditions, oxidation, etc.
- **Particles** can generate odor once they are released in atmosphere, especially particles below 1 micron have a very large total surface area per mg.
- It is impossible to determine odor reduction efficiencies without **olfactometric** measurements, because of the above-mentioned reasons, but a 25% to 50% tolerance on these results are not unusual.
- Odor immission in the surrounding area is occurring **within 1 to 10 minutes** after emission from the stack or building. Odor measurements are allowed to be analyzed within 28 hours after sampling . Odor concentrations are mostly decreasing in time and this change over time is usually not measured.

**THRESHOLDS:** Usually cocktails with extreme low detection thresholds (DT)  
PPM is only a measure for odor if there is only 1 contaminant.



Cocktails are usually complex:  
- Olfactometric analyzes required  
- Nitrogen diluted samples  
(preserve: oxidation, condensation)  
- Keep sample bags clean, dark (UV)



VERY HIGH REMOVAL  
EFFICIENCY MAY BE  
REQUIRED AT  
LOW PPB and PPT CONC.

# Measuring odour: olfactometer

A human nose may detect odour at concentrations well below analytical methods.

A diluted (first above detection) odorous mixture and an odour-free gas (as a reference) are presented separately.

The panellists are asked to report the presence of odour together with a confidence level.

The gas-diluting ratio is then decreased.

The port from which the odorous air is presented is chosen randomly.

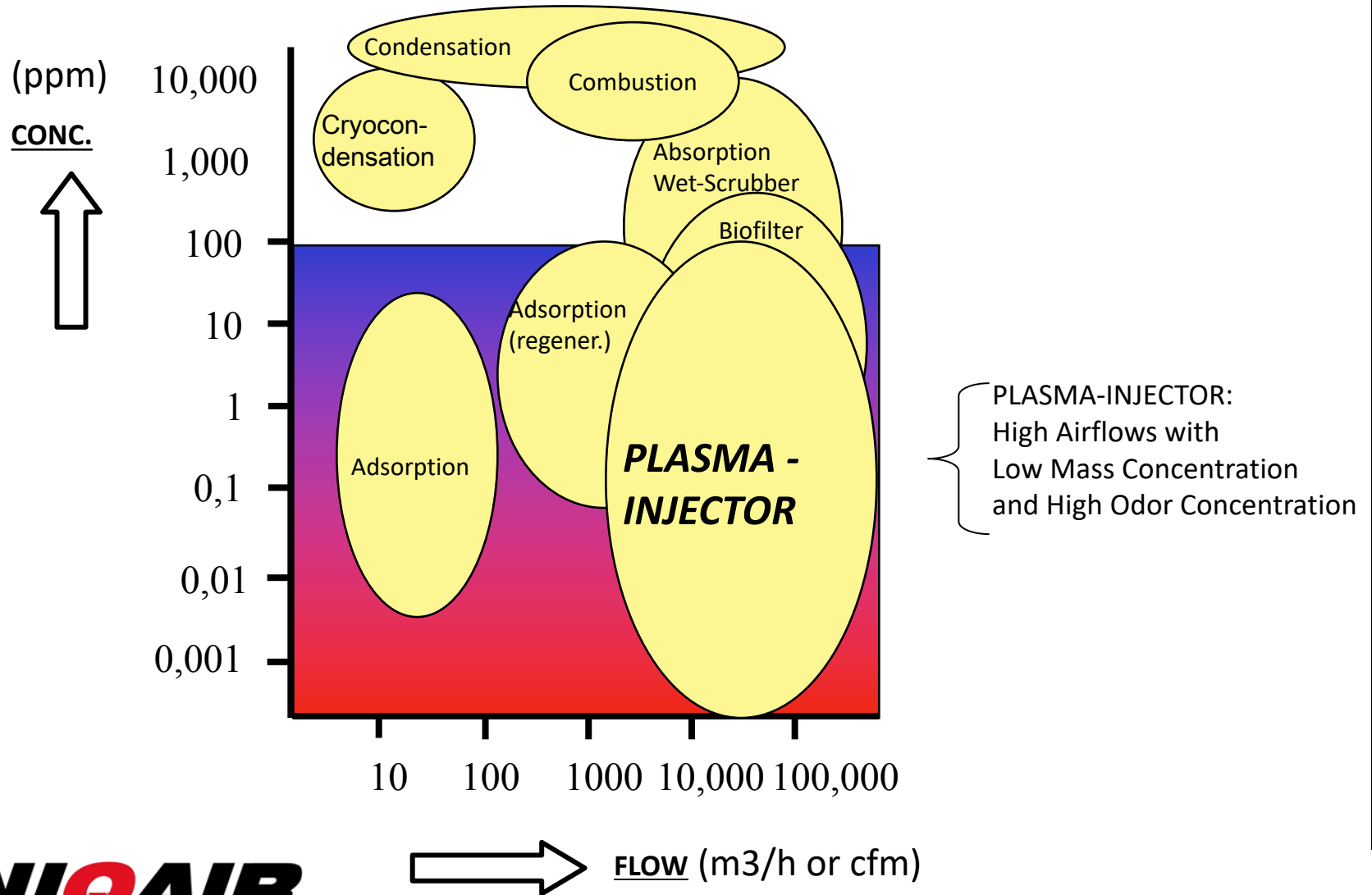
An air sample may need 100,000 dilutions when half of the panelists can detect; concentration = 100,000 odour units/m<sup>3</sup> or DT

## Recommendations testing:

- Dilution of samples with dry N<sub>2</sub> to prevent condensation and preserving the sample in a Tedlar or Nalophan bag,
- Odor lab that complies to the performance requirements of EN13725 re. Accuracy and Repeatability, including annual interlab. ring test.
- Comply to the applicable recommendations EN13725

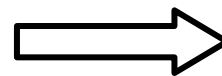
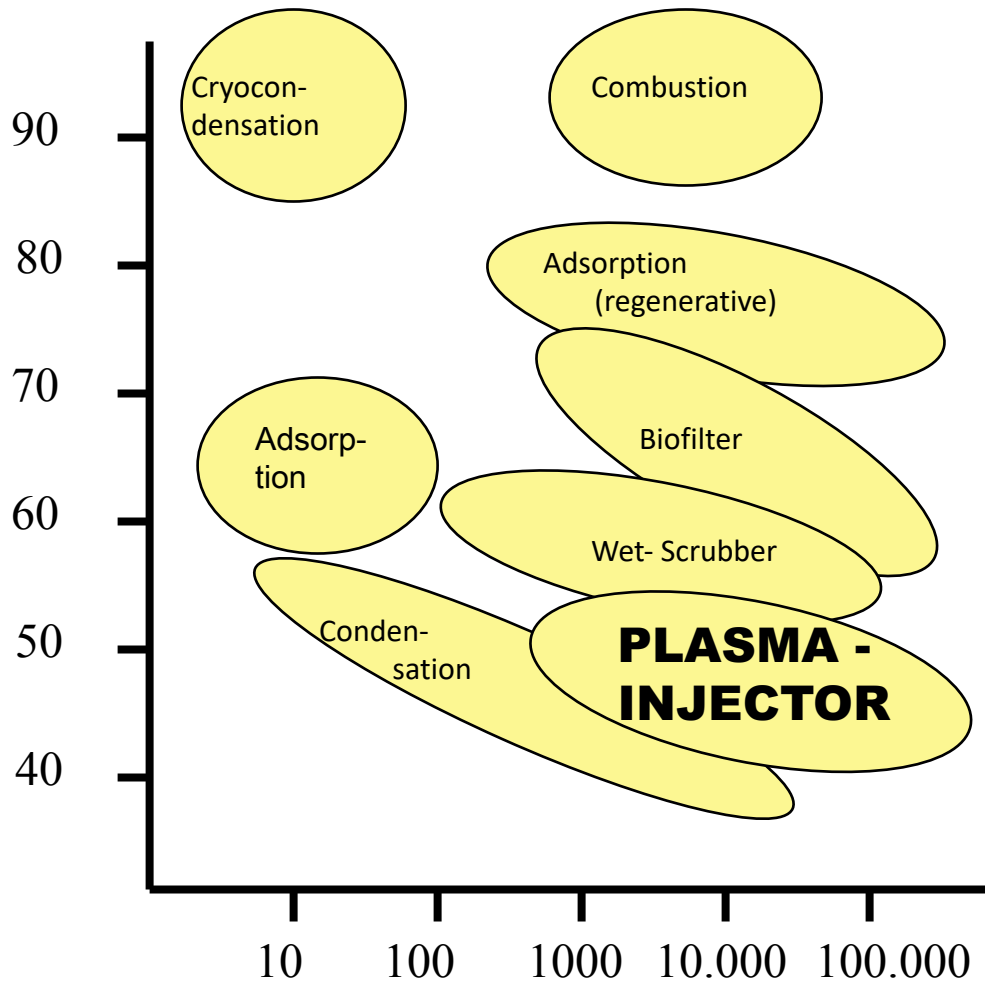
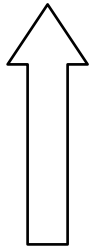


# ODOR CONTROL: low ppm concentration with high DT, ou/m3



# ODOR CONTROL TECHNOLOGIES: investment cost

(% indicative)  
INVESTMENT COST



FLOW (m3/h or cfm)

# ODOR CONTROL: dryers, air conveyors, coolers, etc.

## Validation of criteria for different techniques (project example only)

0 = poor 10 = excellent	Waste- Flow	Area	Energy	Invest. cost	Operat. cost	Life	Easy to operate	Odor reduction	TOTAL
Carbon adsorption	4	4	4	4	2	4	6	<b>1</b>	<b>29</b>
RTO	1	5	1	3	1	6	4	<b>10</b>	<b>31</b>
Bio filtration	8	1	7	7	8	8	7	<b>6</b>	<b>53</b>
Wet-scrubber (chem)	1	4	7	4	2	7	2	<b>7</b>	<b>34</b>
Wet-scrubber (water)	5	4	7	7	8	8	8	<b>4</b>	<b>47</b>
<b>PLASMA -INJECTOR</b>	9	10	7	8	8	9	9	<b>9</b>	<b>69</b>

### Remarks:

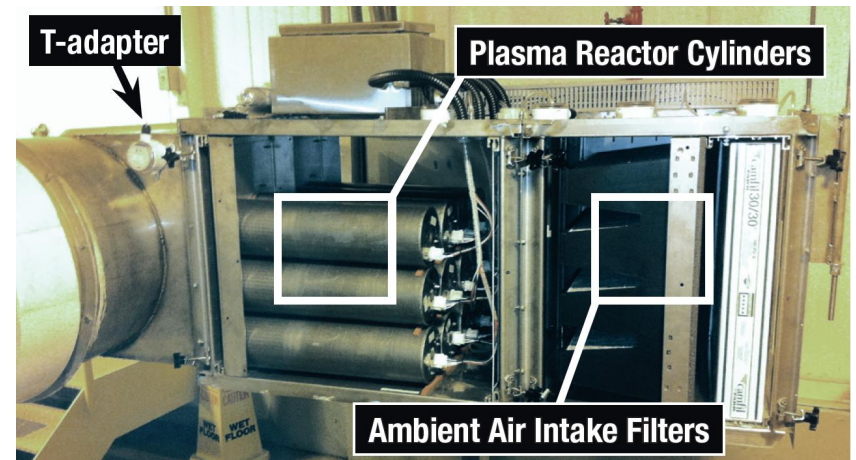
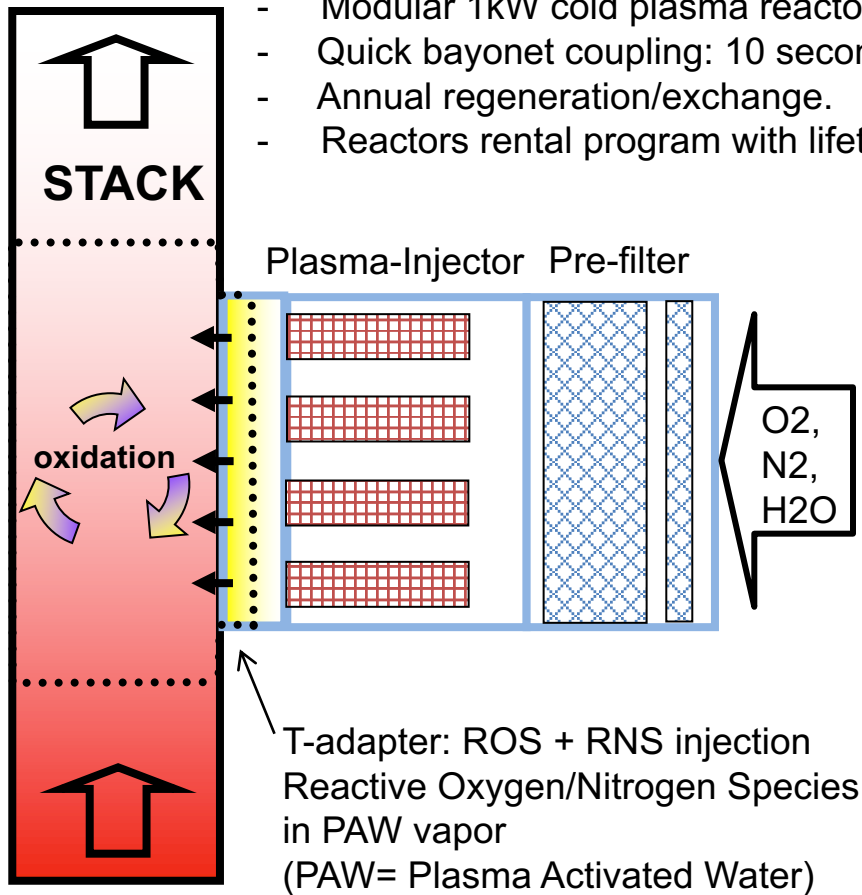
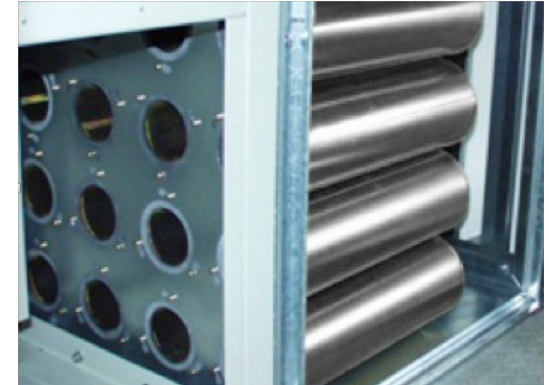
- Carbon adsorption: if temperature and humidity too high, carbon pores can be clogged with water.
- Bio systems (filters/scrubbers): not suitable for intermittent air flow with changing contaminants or with low solubility, bacteria need more constant process conditions and the process can be difficult to control.
- Wet scrubber (water only): has often a low odor reduction efficiency as it is only suitable for odors with good solubility, which is not the case with odors containing fat/proteins.



# PLASMA INJECTION: with T-adapter connection

UNIQAIR Patented Plasma Reactor Cylinders (PRC):

- Modular 1kW cold plasma reactor cylinders
- Quick bayonet coupling: 10 second disconnect
- Annual regeneration/exchange.
- Reactors rental program with lifetime warrantee

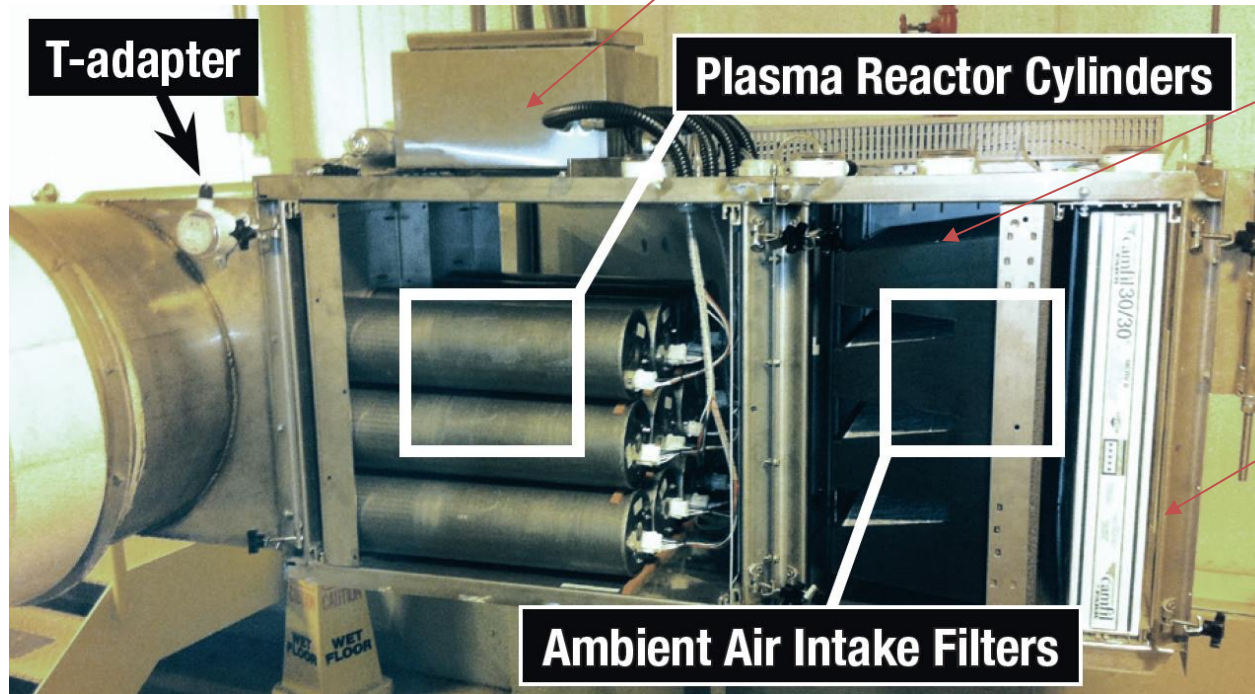


# PLASMA-INJECTOR: PI-120 (12kW)

Food Dryer 15,000 cfm, 25,000 m3/h

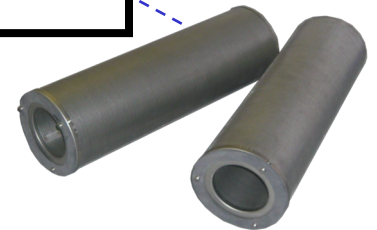
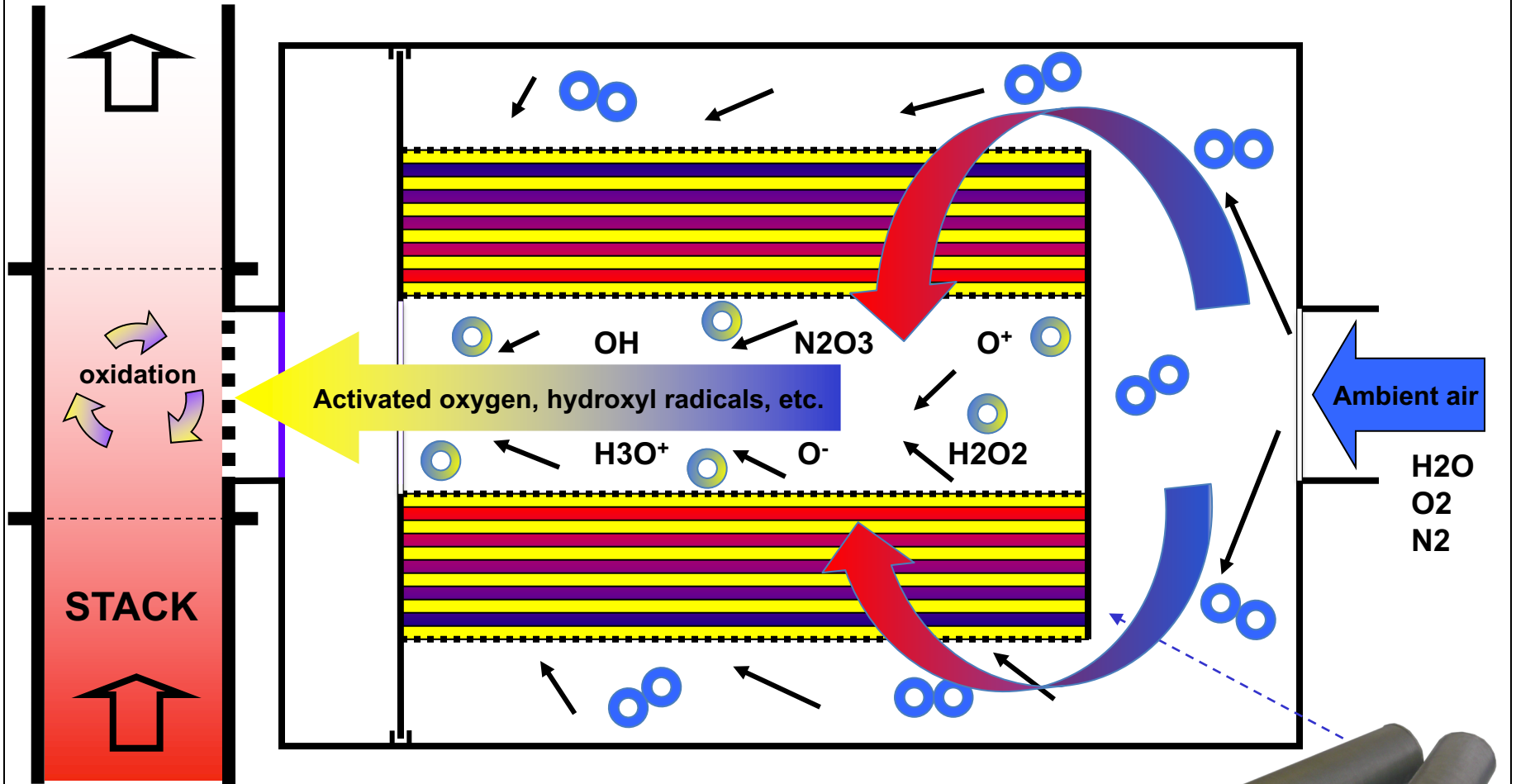
Junction box: all electrical connections pre-wired

High Efficiency filter with Camfil Durafil or CityCarb



First step pre-filter with CamfilFarr type 30/30 pleated filter element.

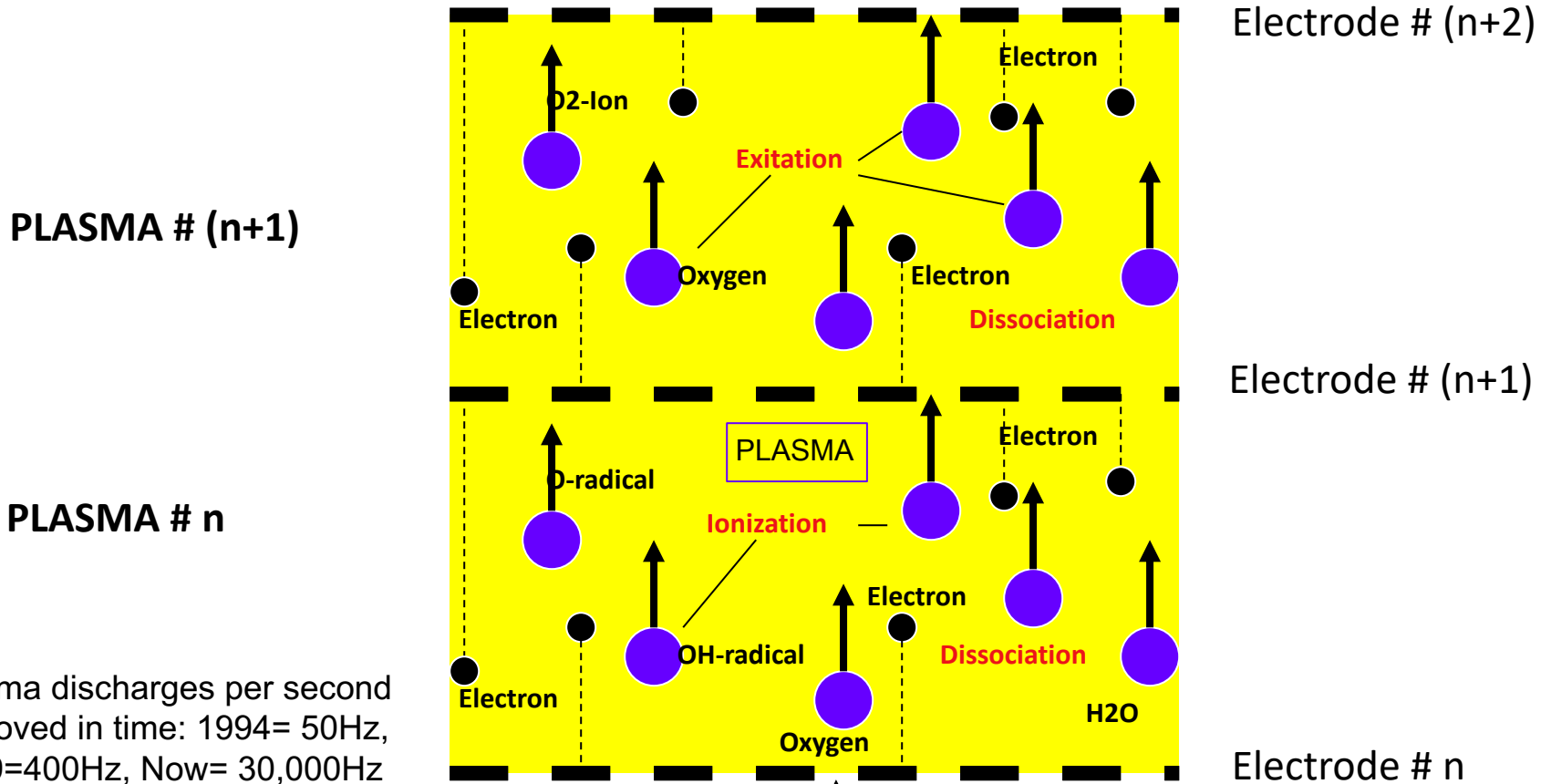
# Modular Plasma Reactors: schematic airflow



# PLASMA REACTOR:



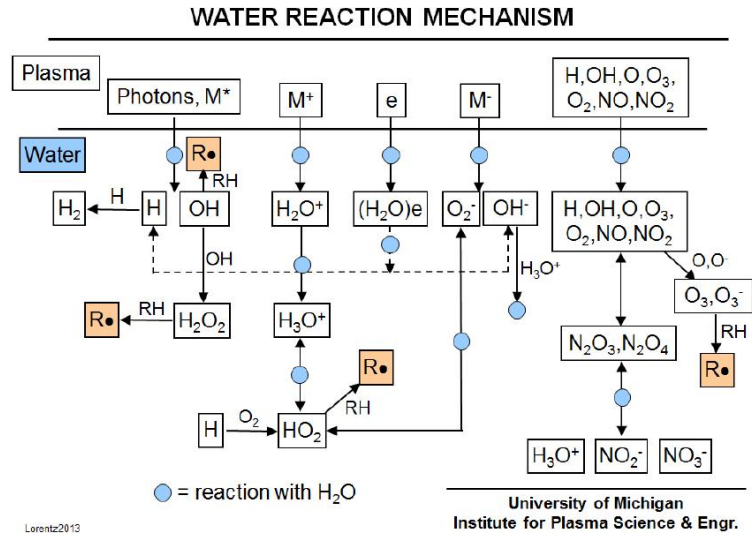
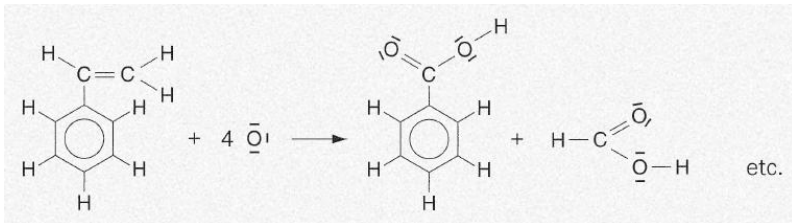
Reactive Oxygen/Nitrogen Species in PAW vapor (PAW= Plasma Activated Water)



Plasma discharges per second improved in time: 1994= 50Hz, 1999=400Hz, Now= 30,000Hz

# Working principle:

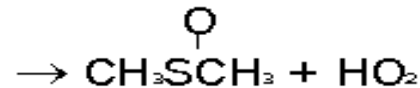
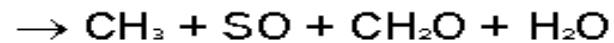
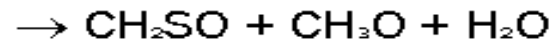
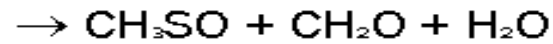
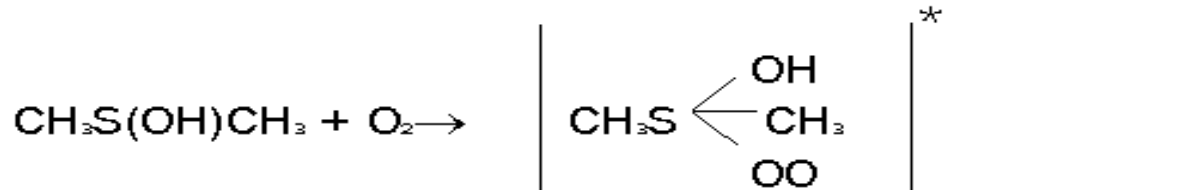
- Oxidation of odor molecules to various levels. (just like nature only faster)
- Ionisation/Polarisation of aerosols and small particles (agglomeration)



- Photo dissociation  $O_2 + h\nu \rightarrow O + O (1D) \quad \lambda < 190 \text{ nm}$
- Ion-electron recombination  $O_3 + h\nu \rightarrow O_2 (1\Delta_g) + O (1D) \quad \lambda < 310 \text{ nm}$
- Electron impact  $O_2 + e \rightarrow O + O (1D)$
- Photo dissociation  $O + e\text{-fast} \rightarrow O (1D) + e\text{-slow}$
- O-atom recombination  $O_2 + h\nu \rightarrow O + O (1S) \quad \lambda < 133 \text{ nm}$
- Etc.  $3O \rightarrow O_2 + O (1S)$

# Example: Dimethyl Sulfide oxidation process

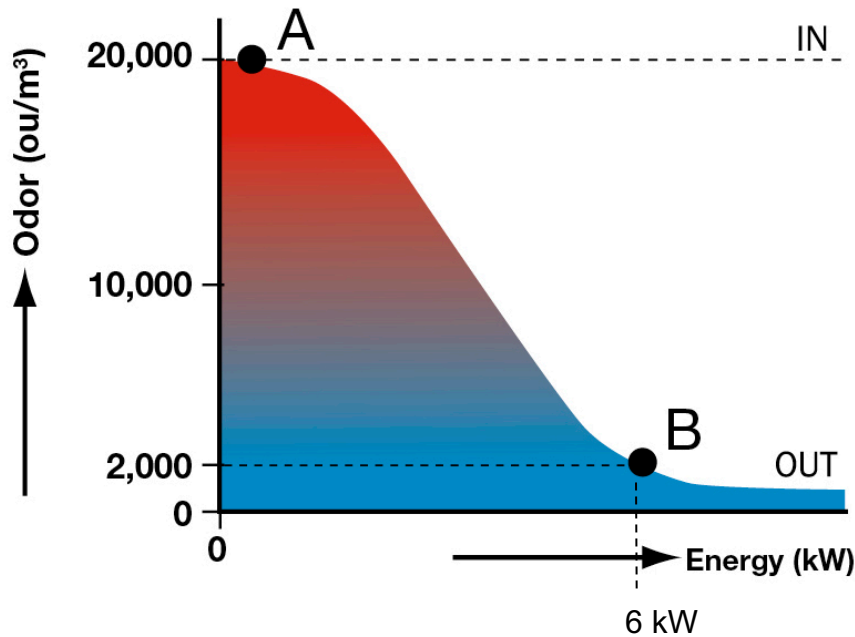
Oxygen and hydroxyl radicals are oxidizing and breaking down odors



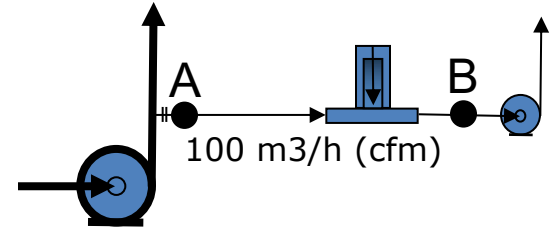
# Odor reduction = function (energy)

More energy input will increase odour reduction until this levels off.

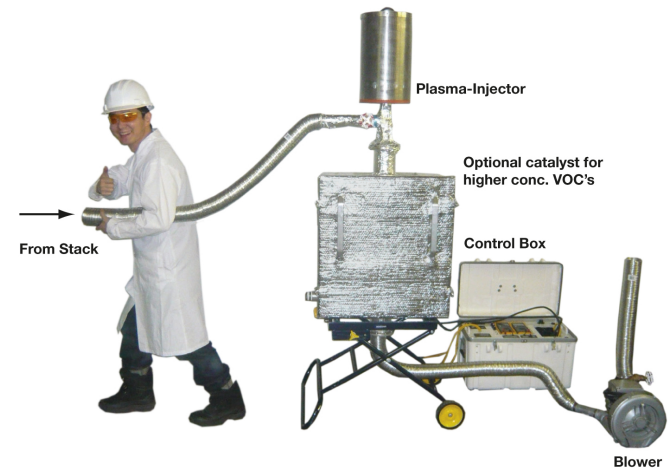
Odor reduction = f (energy)



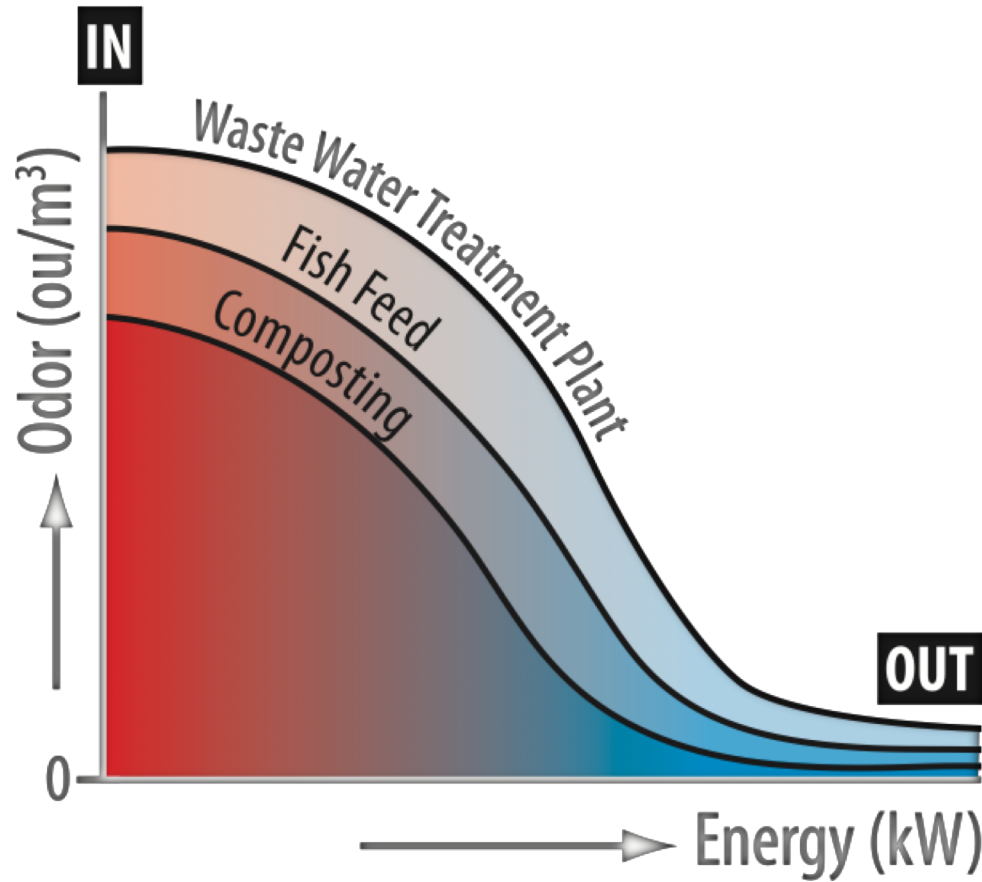
Example 17,000 m<sup>3</sup>/h (10,000 cfm) = 6 kW.



Pilot test units determine required energy

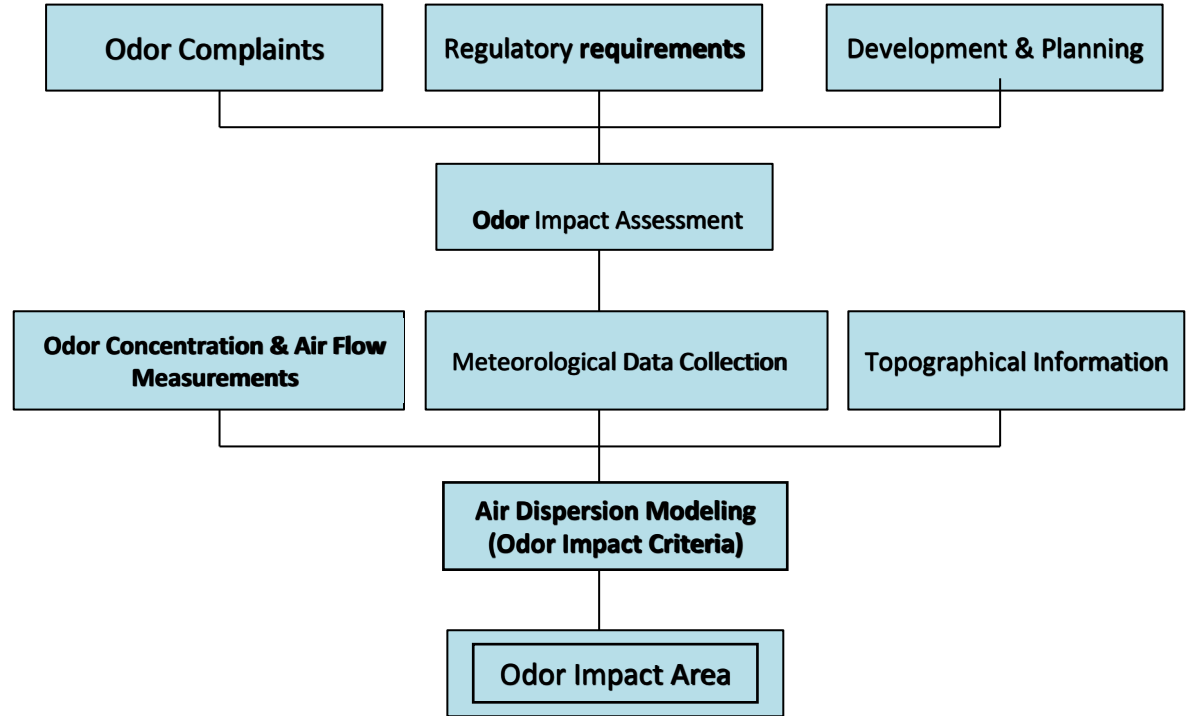
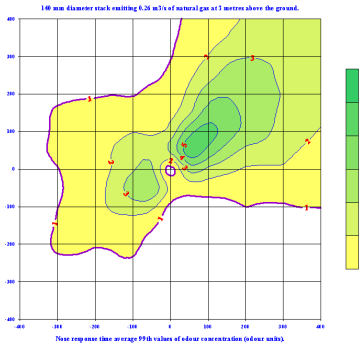
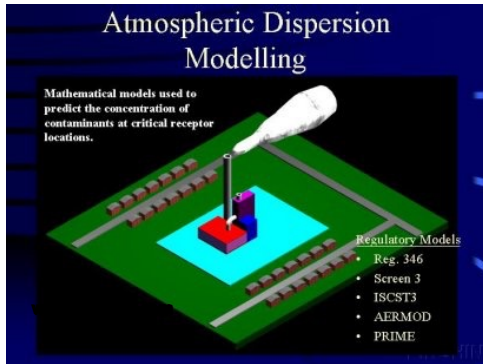


# Odor reduction = function (energy)





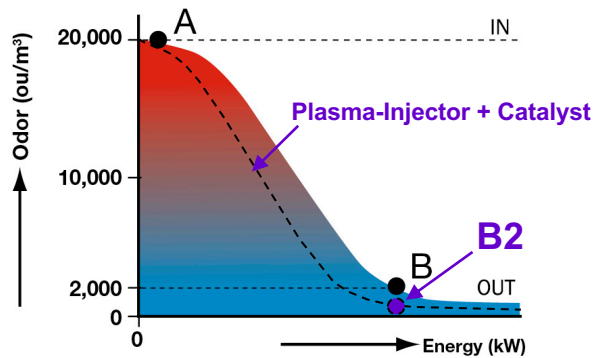
# Odor impact area is defined by plotting isopleths of odor concentration:



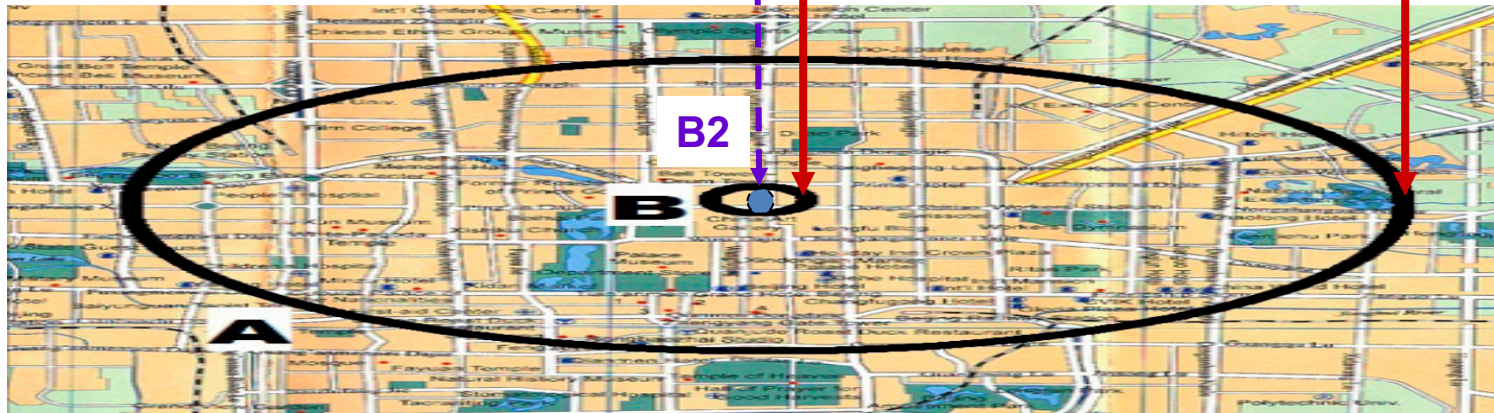
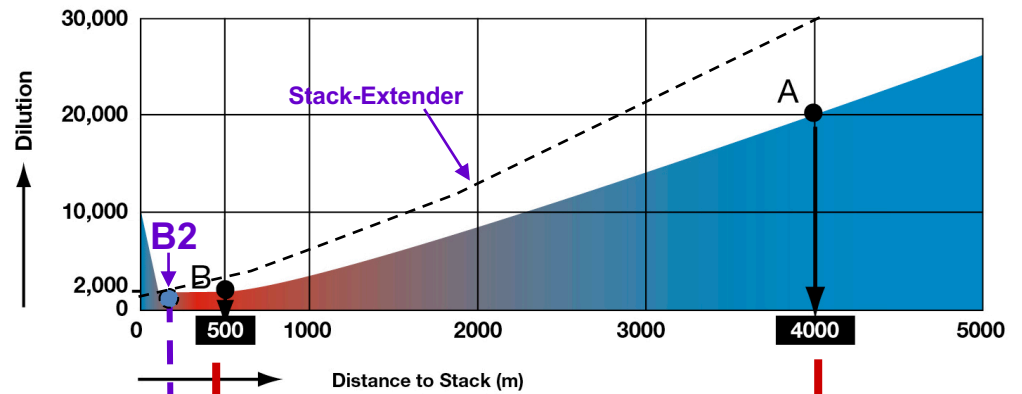
Odor dispersion modeling is required after pilot testing to evaluate required efficiency (energy = size of PLASMA-INJECTOR) and compare before/after treatment situation.

# EXPOSURE LIMIT: choose plasma energy + stack height

Odor reduction = f (energy)

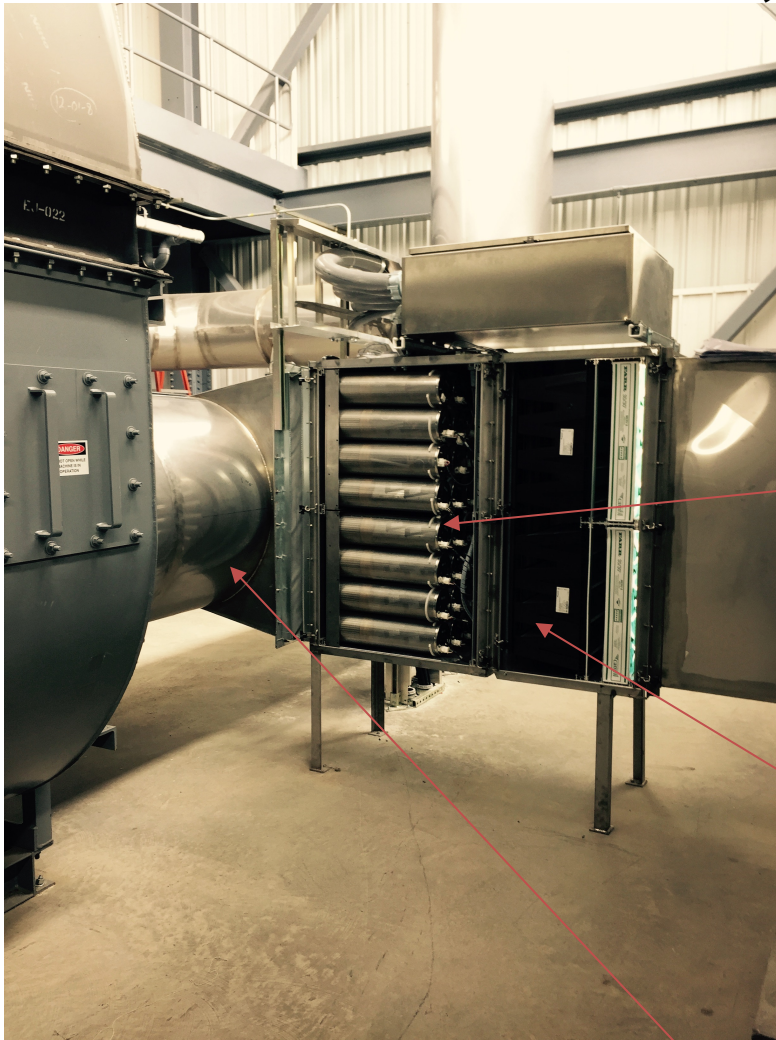


Dilution versus Distance to Stack (example)



# PLASMA-INJECTOR: flash dryer pork/fish/chicken

50,000 m<sup>3</sup>/h (30,000 cfm)



- Automatic on/off,
- No water or chemicals
  - No operator training
  - Virtually maintenance free: no waste

Plasma-Injector  
with PRC  
(Plasma Reactor Cylinders)

Plasma-Injector  
with Pre-Filter  
cabinet attached.



adapter connecting Plasma-Injector to exhaust duct



# Plasma Injection Odor Control

APPLICATION	# SYSTEMS	AIRFLOW M3/H	COUNTRY
Pet food	50	8,000 - 60,000	USA/CA/Belg./Germ./Spain/NL/Turk/S-Kor.
Fish feed	35	5,000 – 75,000	Japan/S-Kor/CA/NL/DK/Greece/Pol./UK/B
Compound feed	13	10,000 – 40,000	UK/NL/Germany/Switzerland
Corn Processing	6	15,000 - 40,000	Turkey/ The Netherlands
Soybean Processing	2	5,000 – 15,000	The Netherlands
Rapeseed Processing	2	10,000 – 45,000	Denmark/Germany
Chicken Manure	2	17,000 – 18,000	The Netherlands
Rice & Flour Processing	2	7,000 – 10,000	Germany
Tobacco drying	2	15,000 - 30,000	Hungary/Serbia
H2S, Mercaptans	4	4,000 – 8,000	India/Belgium/ The Netherlands
Sludge tanks & composting	3	600 – 100,000	The Netherlands
Herbs & Spices	2	10,000 – 7,000	Belgium/ The Netherlands
Coffee & Food, Flavours mfg.	5	4,000 – 55,000	USA/Israel/NL/Germany
Spent Grape Marc drying	2	20,000 – 21,000	Australia
Rendering	2	6,000 - 50,000	USA/Germany

# PLASMA-INJECTOR: air conveyance



T'-adapter connecting Plasma-Injector to exhaust duct

Plasma-Injector PI-30: 3kW

- Automatic on/off,
- No water or chemicals
- Simple operation
- Virtually maintenance free
- Foot print 1' x 5'  
(30cm x 1,500cm)

# Vertical position: injection on top of horizontal air duct

Pre-filter cabinet



Plasma-Injector PI-240V (24kW)  
30,000 cfm

Plasma-Injector PRC cabinet

Junction box: all electrical connections







**12 Stacks: 160,000 cfm = 270,000 m3/h**

**Pet food plant (CA), 3 lines 36t/h.**

**Residents only 600ft/200m from stacks.**



**Plasma-  
Injector**

**1 Plasma-Injector per stack, Foot print: 2ft x 5ft,  
Canopy weather protection.**

**UNIQAIR.COM**  
UNIQUE AIR PURIFICATION

# UNTREATED: Pet Food, 12 stacks > 20 ou/m<sup>3</sup> (DT)

## Results Stack Dispersion Calculations: Odor Concentration Isometric Lines

Modeling Case 1b:  
- Stack ft/s Increased;  
- No stacks treated;  
- Weather: Nov 13  
and Dec 14 (9 odor  
complaints total).

KEY: Odor Units/Cubic Meter  
100: Extremely Strong  
60: Very Strong  
30: Strong  
20: Distinct to Strong  
10: Weak to Distinct  
5: Weak  
1: Very Weak  
0: No Odor

Contours
1.0
2.0
3.0
4.0
5.0
6.0
7.0
10.0
15.0
20.0



Distance nearest residences app. 200m: over 20 ou/m<sup>3</sup> (DT) see **black** line

# TREATED: Pet Food, 12 stacks < 2 ou/m<sup>3</sup> (DT)

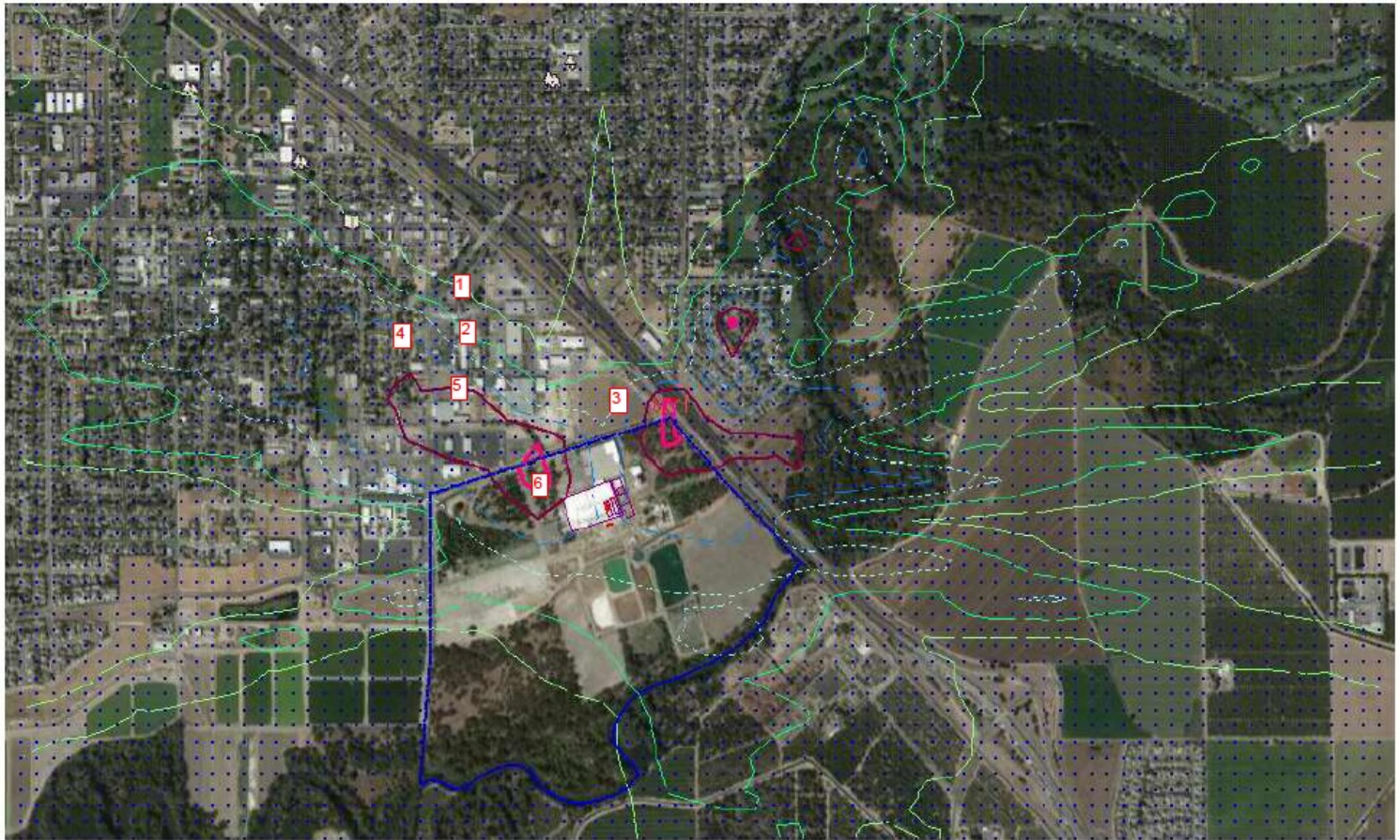
Odor concentration on ground level reduced 90% to 2 from 20 ou/m<sup>3</sup> (DT)

Modeling Case 3b:

- Stack ft/s Increased;
- All stacks treated;
- Weather: Nov 13 and Dec 14 (9 odor complaints total).

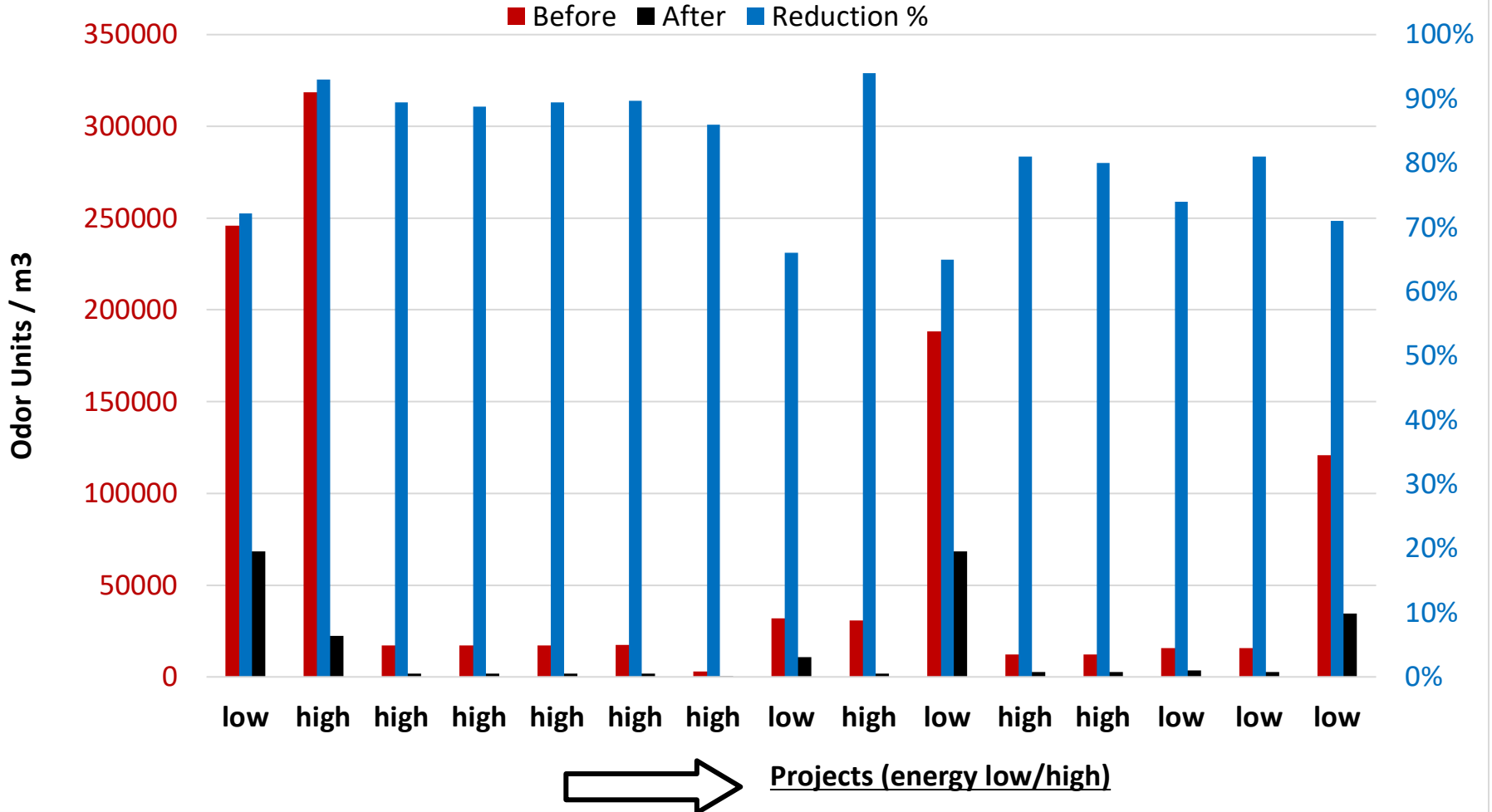
KEY: Odor Units/Cubic Meter  
100: Extremely Strong  
60: Very Strong  
30: Strong  
20: Distinct to Strong  
10: Weak to Distinct  
5: Weak  
1: Very Weak  
0: No Odor

Contours	
1.0	Light Green
2.0	Light Blue
3.0	Light Cyan
4.0	Light Blue-Grey
5.0	Light Blue
6.0	Light Purple
7.0	Light Yellow
10.0	Yellow
15.0	Orange
20.0	Red



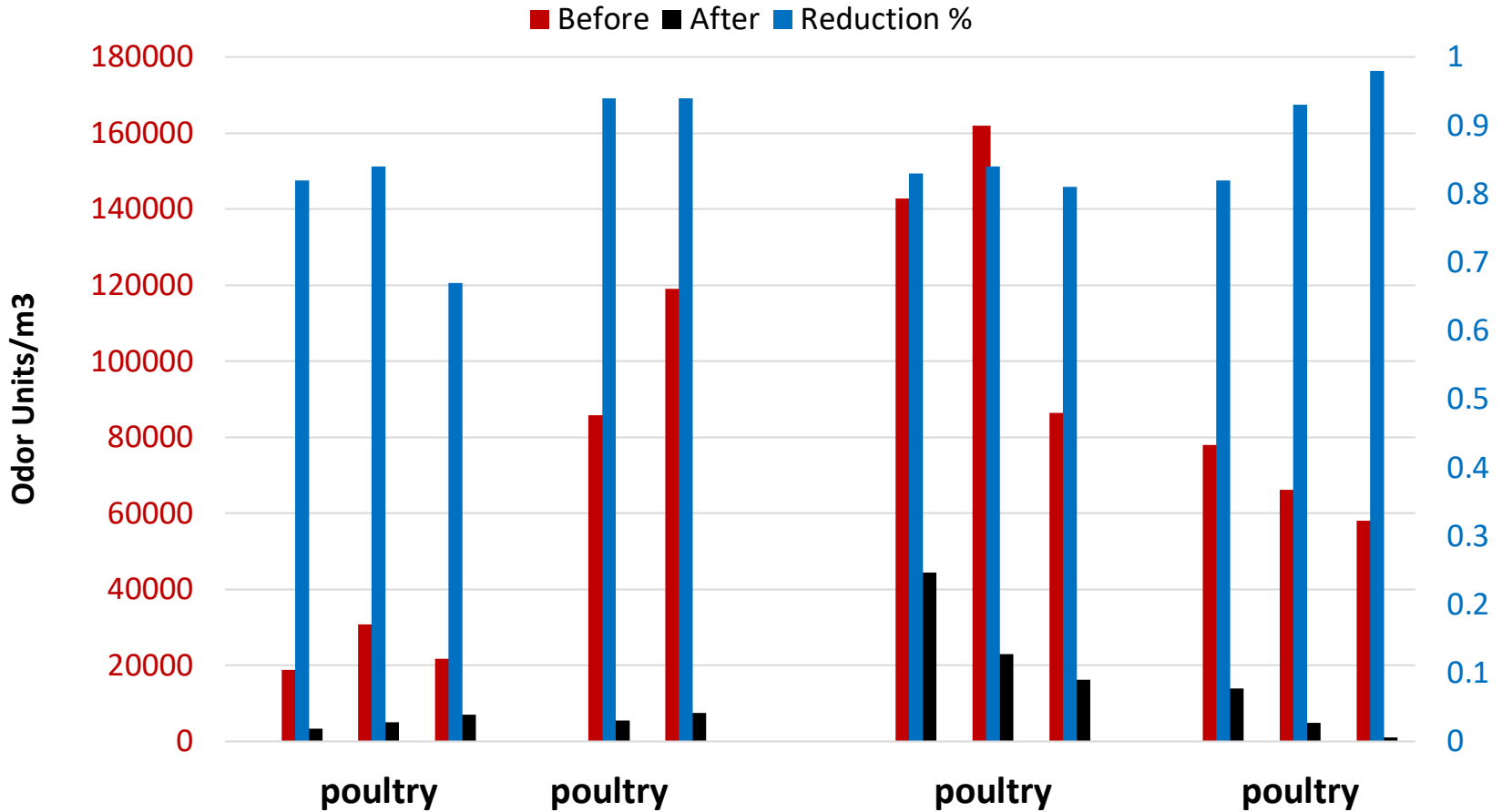
Distance nearest residents app. 200m: to 2 ou/m<sup>3</sup> from 20 ou/m<sup>3</sup> based on 100% of time processing highest odor recipe on days with worst weather conditions (annual average NA).

## Odor Reduction Fish Feed



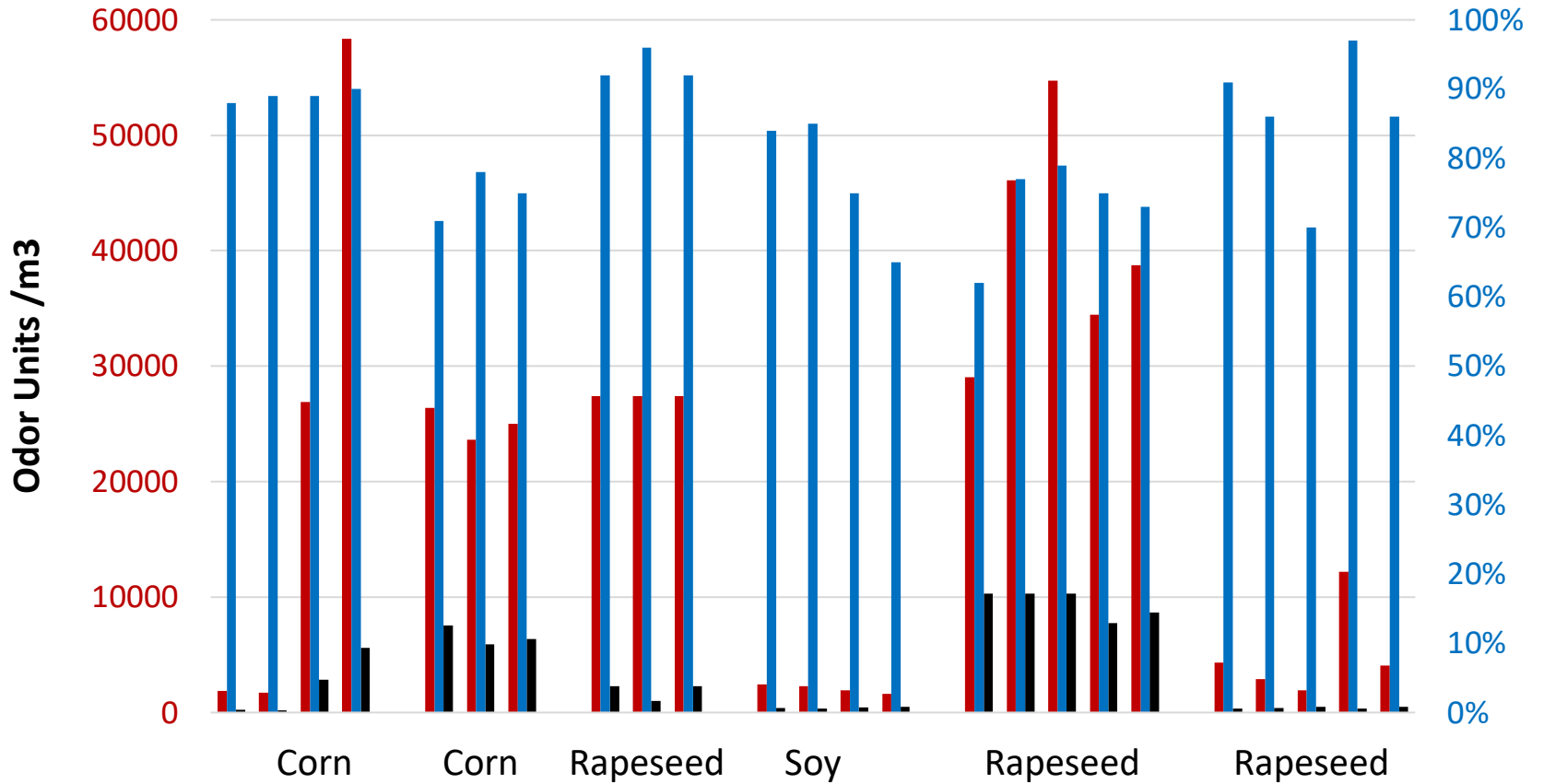


## Odor Reduction Compound Feed

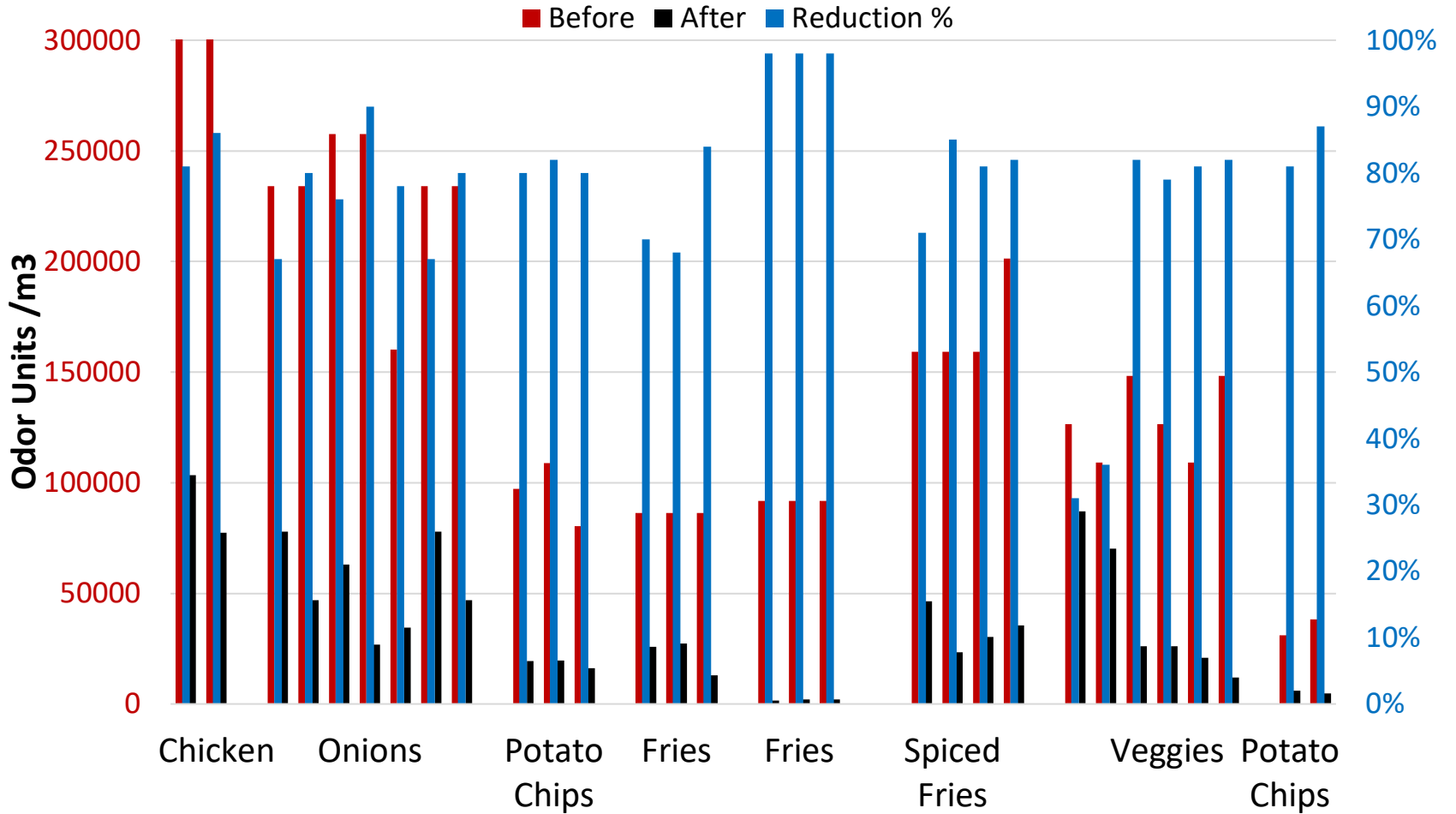


## Odor Reduction Seed Processing

■ Before   ■ After   ■ Reduction %



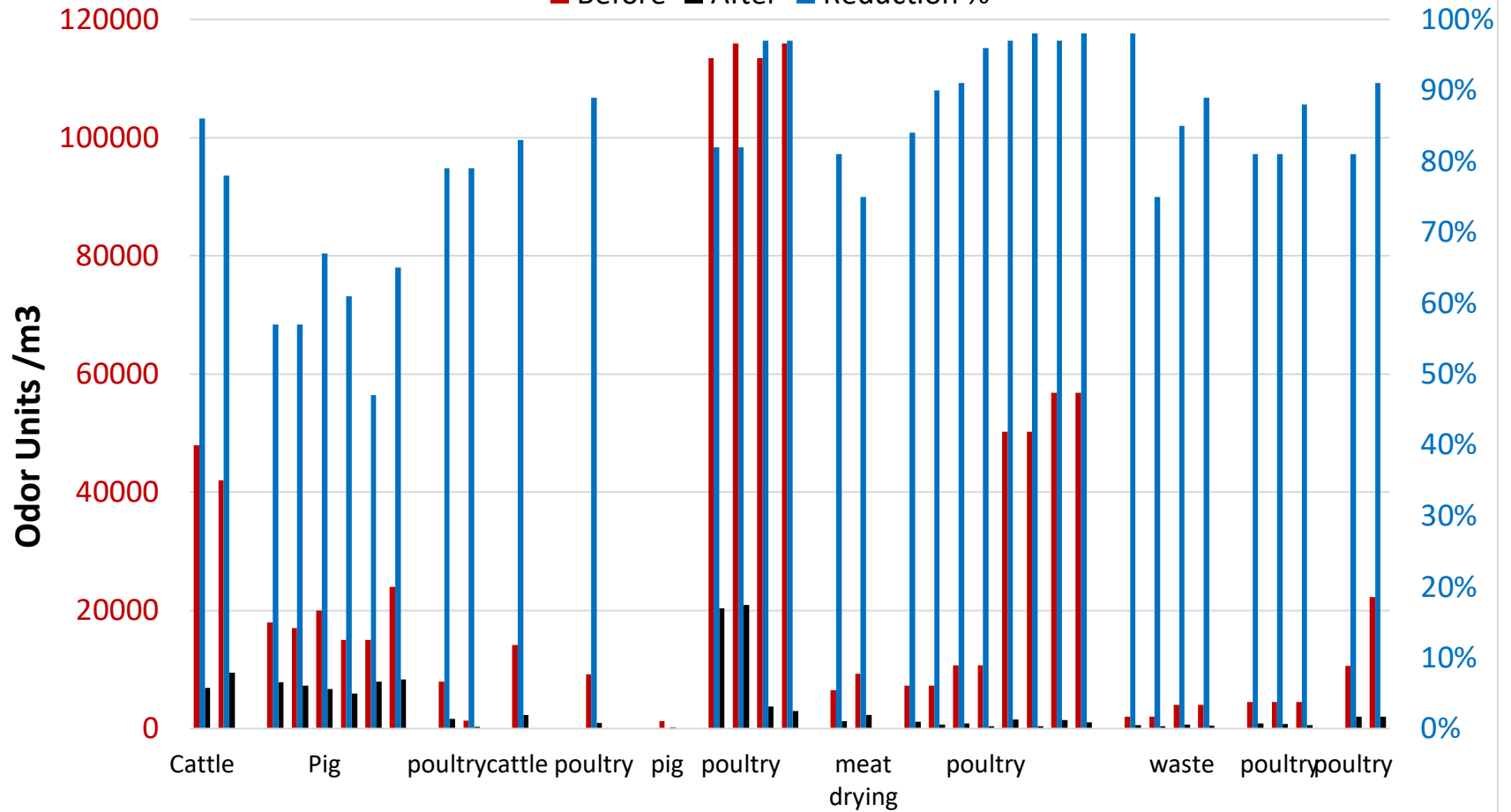
## Odor Reduction Fried Foods





## Odor Reduction Slaughter

■ Before   
 ■ After   
 ■ Reduction %



## **PLASMA-INJECTOR: sustainable cold plasma oxidation**

- High odor removal efficiency 70-95% (DT or ou/m<sup>3</sup>)
- No supply of chemicals, water, fuel, etc.
- No waste at all
- Reliable: no moving parts and only clean air processing
- Low cost, long lifetime > 25 yr
- Plasma reactor rental with lifetime warrantee program
- No impacts from process fluctuations like dust, temperature, humidity etc.
- Simple & safe operation (only on/off, no exposure to kV-parts at all )
- Almost no maintenance: 1 x plasma reactor exchange (15 min) per year, 4x dust filter per year.
- Low energy consumption (example 6kW per 10,000 cfm / 17,000m<sup>3</sup>/h)
- Injection principle: not obstructing production exhaust airflow.
- Safe: all high voltage parts are inside the plasma reactors with annual exchange/regeneration.
- Compact and easy to install at low cost without modification of existing ducts or equipment.